

PATENT SPECIFICATION  
NO DRAWINGS

**1053.331**

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COMPLETE SPECIFICATION

Electrical Resistance Material

We, ELOFOL A.G., a Liechtenstein company, of Vaduz, Liechtenstein, do hereby declare the invention, for which we pray that a Patent may be granted to us, and the 5 method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to an electrical resistance material for the production of resistors, especially laminated resistors, for heating purposes, which comprises a finely divided resistance substance, for example graphite or a finely divided resistance wire alloy, the substance being embedded in and thus bonded 10 by an inert carrier material, for example a synthetic resin or lacquer. By inert carrier material is meant a substance which undergoes no chemical reaction with the other constituents of the resistance material and takes practically no part in the electrical 15 conductivity of the resistance material.

Laminated resistors, which contain graphite, carbon black, metal dust or other conductive substance as the resistance substance solidified 20 with a binder, are known. If these resistors are to be used as heating resistors they require special devices such as thermostats to regulate the temperature and keep it constant 25 as well as to prevent overloading of the resistors.

Laminated resistors made of graphite bonded by synthetic resin are particularly easy 30 to manufacture owing to their simplicity, but have the disadvantage that owing to the negative temperature coefficient of this resistance substance, they take up more current when heated and therefore become still hotter. If 35 any circumstances arise to reduce heat transfer, for example if a piece of furniture is placed in front of the laminated resistor, there is the danger that the resistor itself 40 will be overheated and burnt, which not only destroys the resistor but may cause a fire. For this reason it has not been possible to

use graphite resistors of large surface area for 45 heating purposes. But even in a resistor in which metal powder is used as the resistance substance, the reduction in current consumption which occurs when the resistor is heated, since it has a positive temperature coefficient, is frequently not sufficient to ensure that the resistor will not burn, because the heat transfer may be insufficient.

It is an important problem, particularly 50 for a heating resistor of large surface area, to find an arrangement by which the resistor is not controlled as a whole, for example by being switched on and off by a thermostat, but which ensures that every minute individual area of the resistor will automatically adjust 55 itself according to the temperature load to which it is subjected, and thus adjust its resistance. Such a heating resistor having for example a surface area of 1 square metre would thus have the same resistance value 60 over its whole surface except over a small area of, for example, 100 square centimetres in which transfer of heat may be in some way 65 prevented, where it would have a higher resistance value and where after a slight and quite permissible increase in temperature the heat produced would be considerably diminished.

It is an object of the invention to provide 70 an electrical resistance material which, whilst avoiding the above-mentioned disadvantages, requires no temperature regulating device but alters its resistance value in each unit area of a resistor according to the thermal stress 75 in that area, so that the current consumption and hence the electrical power in that area will not permit the temperature in that to rise above a maximum value depending on the working temperature of the material as a whole, so that localised burning will be 80 avoided.

According to this invention, an electric resistance material has the following con- 85

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stituents:— a finely divided resistance substance, an insulating material, and a non-conductive inert carrier material, the insulating material having a markedly higher specific resistance and a greater coefficient of thermal expansion than the resistance substance such that when the resistance material is heated the insulating material expands to a greater extent than the resistance substance and thus increases the resistance to current flow between the particles of resistance substance.

It is essential that, in the resistance material of the invention, the resistance substance, the insulating material and the carrier material be clearly separate and distinct components of the resistance material and not interchangeable. In contradistinction to this essential requirement, a resistance material is known having only two clearly separate and distinct components, viz. a resistance substance and a thermally expansible non-conductive carrier material of special properties. It is also known that the latter carrier material may have two constituents, for example polyethylene and polytetrafluoroethylene, but these constituents form a mixed synthetic material acting as a unitary whole to give a special thermally expansible property; they do not act separately in so far as their insulating properties are concerned.

If the finely divided resistance substance is metallic and has a positive temperature coefficient, the temperature coefficient of the resistance material will be of a greater value than that which would be expected from the temperature coefficient of the metal, whereby a resistor made of the resistance material is rendered considerably more fireproof. Further, if graphite or other resistance substance with a negative temperature coefficient is used, which is in itself an advantage, the negative temperature coefficient is as it were converted into a positive temperature coefficient of the resistance material as a whole and it is only by virtue of this that the use of graphite as a resistance substance, with its attendant advantages, becomes possible at all.

When there is a rise in temperature of a whole or a part of a resistor, e.g. in the form of a foil made of the resistance material, the insulating material takes up a larger volume than the resistance substance so that either the contact between the individual particles of the resistance substance is impaired due to the fact that they are forced apart by the expanding particles of insulating material or the insulating material, for example if it is liquid, will be forced between the individual particles of the resistance substance and thus considerably increase the resistance to current flow between these particles. The resistance value of such a resistor will thus vary from point to point according to the temperature at each point, so that such a resistor, which is particularly suit-

able for heating, can be regarded as a resistor controlled by a large number of individual thermostats in each minute area.

A particular advantage which provides for simple manufacture of a resistor and advantageous electrical behaviour is achieved if the insulating material is liquid below a desired maximum temperature of the resistor, and preferably even at the working temperature, or becomes liquid at that temperature, or at least softens to such an extent that it can undergo plastic deformation. In that case, the insulating material is added to the resistance substance before the latter is introduced into the inert carrier material. In a resistor produced in this way, the insulating material in use is pushed between the individual particles of resistance substance as it becomes soft under increased thermal stress, thereby increasing the resistance to current flow between the particles.

If a solid substance such as glass powder is used as the insulating material, the introduction of the finely divided resistance substance and of the insulating material into the inert carrier material may be carried out in any desired sequence.

For practical use, graphite powder and finely divided iron alloys (resistance wire alloys) have proved to be suitable resistance substances. Suitable for use as the insulating material is any material whose specific resistance is markedly above that of the resistance substance, e.g. materials having a resistivity of  $10^5$  Ohm cm. when graphite with a resistivity of  $8.10^2$  Ohm cm. is used, and which have a greater coefficient of thermal expansion than the resistance substance.

For the manufacture of the resistors, the resistance material may be applied to an additional rigid or flexible carrier. Alternatively, such a carrier may be partly or completely impregnated with the resistance material. Alternatively, the resistance material may be formed into a self-supporting foil or other profiled member not requiring an additional carrier.

The examples given below illustrate a number of compositions which have been used for resistance materials according to the invention.

#### EXAMPLE 1

Resistance material consisting of:—

9620 g polystyrene

3500 g graphite

650 g fire soot

350 g Mobil oil "Gargoyle" Vactra 2  
("Gargoyle" is a Registered Trade  
Mark).

This mixture was applied to a thickness of  $2\mu$  on a paper support; when a voltage of 220 V was applied, the foil was heated to a maximum of about 44° C. at a room

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temperature of 10° C. no matter how much heat transfer was blocked.

**EXAMPLE 2**

5 Resistance material consisting of:  
5800 g "Versamid" (Registered Trade  
Mark).  
2500 g fire soot  
600 g Trafo oil

10 Application as in Example 1; maximum  
temperature reached was about 24° C. at a  
room temperature of 10° C.

**EXAMPLE 3**

15 Resistance material consisting of:  
5800 g "Versamid"  
3300 g graphite  
940 g iron powder  
520 g beeswax

20 Application as in Example 1; maximum  
temperature reached was about 16° C. at a  
room temperature of 10° C.

**EXAMPLE 4**

25 Resistance material consisting of:  
9620 g polystyrene  
3300 g graphite  
650 g fire soot  
450 g beeswax

30 Application as in Example 1; maximum  
temperature reached was about 27° C. at a  
room temperature of 10° C.

**EXAMPLE 5**

35 Resistance material consisting of:  
5800 g "Versamid"  
4000 g iron powder  
520 g beeswax

40 Application as in Example 1. The foil  
had low conductivity and was for use at volt-  
ages e.g. above 500 V. Maximum temperature  
reached was about 27° C. at a room tempera-  
ture of 10° C.

**EXAMPLE 6**

45 Resistance material consisting of:  
5800 g "Versamid"  
3300 g graphite  
940 g iron powder  
525 g silicone oil

50 Application as in Example 1; maximum  
temperature reached was about 33° C. at a  
room temperature of 10° C.

**EXAMPLE 7**

55 Resistance material consisting of:  
9620 g polystyrene  
3500 g graphite  
650 g fire soot  
600 g silicone oil

Application as in Example 1; maximum  
temperature reached was about 30° C. at a  
room temperature of 10° C.

**EXAMPLE 8**

Resistance material consisting of:  
5800 g "Versamid" 60  
3300 g Graphite  
3300 g powdered glass  
940 g iron powder

Application as in Example 1; maximum  
temperature reached was about 20° C. at a 65  
room temperature of 10° C.

**EXAMPLE 9**

Resistance material consisting of:  
7500 g polystyrene 70  
3300 g graphite  
650 g fire soot  
400 g "Celon" (Registered Trade  
Mark).

Application as in Example 1; maximum  
temperature reached was about 25° C. at 75  
a room temperature of 10° C.

**WHAT WE CLAIM IS:—**

1. Electric resistance material having the  
following constituents:— a finely divided re-  
sistance substance, an insulating material, and  
a non-conductive inert carrier material, the  
insulating material having a markedly higher  
specific resistance and a greater coefficient  
of thermal expansion than the resistance sub-  
stance such that when the resistance material  
is heated the insulating material expands to  
a greater extent than the resistance substance  
and thus increases the resistance to current  
flow between the particles of resistance sub-  
stance. 80

2. Material according to claim 1 wherein  
the resistance substance is graphite or a  
resistance wire alloy. 85

3. Material according to claim 1 or claim  
2, wherein the resistance substance is in pul-  
verulent form. 95

4. Material according to any preceding  
claim, wherein the carrier material is a syn-  
thetic resin. 100

5. Material according to claim 3, wherein  
the grains of the pulverulent resistance sub-  
stance are enveloped by the insulating  
material. 105

6. Material according to claim 1 wherein  
the insulating material is liquid below the  
desired maximum temperature. 110

7. Material according to claim 6 wherein  
the insulating material is liquid at the desired  
working temperature. 115

8. Material according to claim 1, wherein  
the insulating material is plastically deform-  
able at the desired maximum temperature. 120

9. Material according to claim 8 wherein  
the insulating material is plastically deform-  
able at the desired working temperature. 115

10. Material according to claim 1, where-  
in the insulating material is powdered glass.

11. Electric resistance materials substan-  
tially as herein described, with reference to  
the examples. 120

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12. An electric resistance heating element comprising a foil of resistance material according to any preceding claim.

WITHERS & SPOONER,  
Chartered Patent Agents,  
148-150, Holborn,  
London, E.C.1,  
Agents for the Applicants.

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